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54 **LASER SCANNER.**

57 The laser scanner is provided with a scanner temperature sensor (3) disposed near a position sensor (2) and control means (6) for compensating for temperature on the basis of the output from the temperature sensor. Accordingly, position accuracy can be improved drastically and minute machining can be made with a high level of accuracy.

SPECIFICATION

APPARATUS INCLUDING A LASER SCANNER

TECHNICAL FIELD

The present invention relates to an apparatus including a laser scanner and more particularly to a function for preventing a positional deviation of the apparatus with respect to a machining position of the latter, the positional deviation being caused by variation in temperature of an environment temperature and variation in temperature of a scanner appearing as the apparatus is used.

BACKGROUND ART

As the semiconductor technology is advanced, a variety of elements produced of semiconductor are miniaturized more and more so that a requirement for improvement of the current fine machining technique has been raised up.

Particularly, the laser machining technique has the following advantageous features compared with mechanical machining, electronic machining and chemical machining each of which has been hitherto employed.

- (1) It can obtain a very high density of output power.
- (2) Since it is non-contact machining, distortion and deformation of a workpiece as seen after completion of

machining compared with its state before machining can be suppressed to a minimized level.

(3) It is possible to perform local machining.

(4) Machining can be performed in an arbitrarily selected atmosphere. (Since there is no need of allowing the workpiece to be placed in vacuum, it can be performed at an inexpensive cost compared with the conventional electron beam machining.) In view of the above-mentioned advantageous features, the laser machining has been widely employed in many utilization fields such as marking on the very fine part of a workpiece, trimming of thick film or thin film resistance, annealing of semiconductor and so forth.

An important consideration to be taken during a step of laser machining is to control the position where a laser beam is radiated. To this end, a scanner for which a laser beam is used (hereinafter referred to as a laser scanner) adapted to perform the positional controlling by actuating a mirror is usually used.

This laser scanner is a device which is provided with a position sensor 2 as shown, for example, in Fig. 4 so that the position where a laser beam is radiated is controlled by actuating a mirror 10 by means of a magnetic driver 9 on the basis of positional data detected by the position sensor 2.

With respect to the conventional laser scanner, to

assure that positional controlling is exactly performed for the axis of the scanner, there is a need of setting a strict operative condition. Especially, when a laser beam is practically radiated in a factory shop, it is required that its temperature property is particularly stabilized. This is because of the fact that it is required that operation is performed under an environmental condition which could not be presumed by anybody as far as the experimental level is concerned.

To assure that the temperature property is stabilized, such a method that a heater H is arranged round a position sensor 2 in a scanner 1 as shown in Fig. 5 so that the position sensor section is heated up to and maintained at a temperature of about 40 °C at all times by controlling the temperature of an electric power supply source to which the heater H is connected is employed for a laser scanner manufactured, e.g., by General Scanning Corp. (U. S. A.). Fig. 6 illustrates a relationship between a laser scanner b of the type including a heater for the purpose of heating and temperature maintaining and a standard type laser scanner a without any heater used therefor, with respect to temperature and time. As is apparent from the drawing, the laser scanner of the first-mentioned type has an advantageous feature that an operating temperature can be stabilized more reliably than the standard type laser

scanner but it has been found that it has the following problems.

- (1) It has an elongated period of running time (30 minutes).
- (2) The environment temperature required for operation of the laser scanner is restricted in the range of 10 to 28 °C.
- (3) It is problematic from the viewpoint of environment and practical installation that it is employed on the general industrial base because of the problems as mentioned in the preceding paragraphs (1) and (2).
- (4) Since controlling is performed for a quantity of heat generated by the heater, it has a slow responsiveness to variation in temperature of the environment and moreover a drift can not be suppressed completely.

The present invention has been made with the foregoing background in mind and its object resides in providing an apparatus including a laser scanner which assures that positional controlling can be performed for the axis of a scanner with high accuracy without any occurrence of temperature drift irrespective of variation in temperature of the scanner.

DISCLOSURE OF THE INVENTION

To accomplish the above object, the present invention

provides an apparatus including a laser scanning usable for the purpose of controlling the position where a laser beam is radiated (representative of the direction of scanning by turning a mirror by driving means adapted to be actuated in response to a signal detected by a position sensor, wherein the apparatus further includes a scanner temperature sensor located in the proximity of the position sensor and controlling means for compensating the temperature of the position sensor on the basis of an output from the scanner temperature sensor whereby operation of the driving means is controlled by the controlling means.

The controlling means is constructed, e.g., such that it is provided with environment temperature detecting means for detecting a scanner atmosphere, i.e., an environment temperature to compare the environment temperature with the temperature of the position sensor section at all times and the position sensor section is heated or cooled by driving heating/cooling means in dependence on results derived from the foregoing comparison so that the temperature of the position sensor section is maintained constant at all times.

Further, as other example, the controlling means is so constructed that it includes setting means adapted to set a data correction table while a positional deviation caused by variation in temperature has been previously detected and means for controlling the driving of a scanner on the basis

of the data correction table and a value detected by the scanner temperature sensor.

With respect to an example of the aforementioned examples where controlling means including environment temperature detecting means is used, since variation in temperature of the scanner due to the environment temperature and the frequency of usage is compensated by the heating/cooling means so that the temperature of the scanner is kept constant at all times, this causes the range of an operation temperature to be widened so that positional controlling can be performed with high accuracy to properly respond to any rapid variation of temperature.

In addition, according to another example of the aforementioned examples, correction values ΔX_m and ΔY_m in n stages represented by G_1 to G_n has been previously set by a number of experiments, e.g., in dependence on a required degree of accuracy, as shown in Fig. 3(b) and the following table. In Fig. 3(b), an ordinate represents an amount of deviation (rad.) and an abscissa does a value of increase in the temperature of the scanner from the initial value. A deviation (Δt) from the initial temperature is calculated on the basis of a value detected by the scanner temperature sensor so that a stage G_m corresponding to the calculated deviation is determined.

Then, correction positions are obtained in accordance

with equations (1) and (2) selected from the following table to correspond to the central values at the stage G_m which has been determined in that way.

$$X = X_o + \Delta X_m \quad \text{--- (1)}$$

$$Y = Y_o + \Delta Y_m \quad \text{--- (2)}$$

(where X_o and Y_o represent coordinates detected by the position sensor.) Then, the mirror is driven in dependence on the obtained correction positions. Since this method is practiced in such a manner that correction is made on the basis of variation in temperature of the scanner, it is possible to radiate a laser beam with a high positional accuracy.

TABLE

	X	Y
G1	$X_o + \Delta X_1$	$Y_o + \Delta Y_1$
G2	$X_o + \Delta X_2$	$Y_o + \Delta Y_2$
G3	$X_o + \Delta X_3$	$Y_o + \Delta Y_3$
G4	$X_o + \Delta X_4$	$Y_o + \Delta Y_4$
	:	:
	:	:
G_m	$X_o + \Delta X_m$	$Y_o + \Delta Y_m$
	:	:

	:	:
Gn	Xo + Δ Xn	Yo + Δ Yn

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view illustrating an apparatus including a laser scanner in accordance with a first embodiment of the present invention, Fig. 2 is a flowchart illustrating operations of the control unit used for the apparatus in Fig. 1, Fig. 3(a) is a schematic view illustrating an apparatus including a laser scanner in accordance with a second embodiment of the present invention, Fig. 3(b) is a diagram illustrating a relationship between differential temperature and amount of deviation, Figs. 4 and 5 are a schematic view illustrating a conventional apparatus including a laser scanner, respectively, and Fig. 6 is a diagram illustrating a relationship between time and temperature with respect to the laser scanner shown in Figs. 4 and 5.

BEST MODE FOR CARRYING OUT THE INVENTION

Now, the present invention will be described in a greater detail hereinafter with reference to the accompanying drawings which illustrate preferred embodiments thereof.

Fig. 1 is a schematic view illustrating a laser scanner

including a laser scanner in accordance with a first embodiment of the present invention.

The apparatus has a characterizing feature which consists in that it includes a scanner temperature sensor 3 located in the proximity of a scanner position sensor 2 in a scanner 1, an environment temperature sensor 4 adapted to detect the environment temperature, a first comparator 5 for comparing a value detected by the temperature sensor 3 with a value detected by the temperature sensor 4, a control unit 6 for controlling the temperature of the scanner position sensor 2 on the basis of an output from the first comparator 5 and an intensity of electric current indicative of a positional command to be inputted therein as a command monitoring signal and a heating/cooling unit 7 comprising a Peltier element to heat or cool the scanner position sensor 2 in response to a command from the control unit 6.

Since other components constituting the apparatus exclusive those as mentioned above are substantially identical to those for the conventional apparatus as shown in Fig. 4, same or similar components to those in Fig. 4 are identified by same reference numerals. In Fig. 1, reference numeral 8 designates a second comparator for comparing a feedback signal i_f from the scanner position sensor 2 with a positional command signal i_o to be inputted in the control unit 6 so as to output a driving electric current to a

magnetic driver 9 and reference numeral 10 does a mirror adapted to be turned by the magnetic driver 9.

Next, operation of the apparatus will be described in the following.

First, when a position command signal i_o indicative of the existent position is inputted in the second comparator 8, the latter compares the positional command signal i_o with a feedback signal i_f from the position sensor 2 so that a driving electric current Δi is fed to the magnetic driver 9 on the basis of results derived from the above comparison. This causes the mirror 10 to be turned in response to turning moment of the scanner 1 by a predetermined quantity.

On the other hand, the positional command signal i_o is inputted in the control unit 6 as a command monitoring signal.

Then, a command signal is issued to the heating/cooling unit 7 from the control unit 6 with reference to the results derived from the comparison of an output from the scanner temperature detector 3 with an output from the environment temperature detector 4 in the presence of the first comparator 5 as well as the aforementioned command monitoring signal whereby controlling is performed so as to allow the temperature of the scanner position sensor section to be kept constant at all times.

Fig. 2 is a flowchart which illustrates by way of

example operations of the control unit 6. Here, when it is assumed that T_1 designates a temperature detected by the scanner temperature detector 3, T_2 does a temperature detected by the environment temperature detector 4, Δt does $T_1 - T_2$ and i_c does a command electric current of which intensity is determined so as to set a condition as identified by $\Delta t = 0$.

With the apparatus constructed in the above-described manner, the temperature of the position sensor section and the environment temperature are continuously detected so that controlling is performed in dependence on values of the temperatures so as to allow the temperature of the position sensor section to be kept constant at all times. This makes it possible to properly control with high accuracy at all times the position where a laser beam is radiated, irrespective of how rapidly these temperatures vary.

Incidentally, the present invention has been described above as to the embodiment wherein a Peltier element is employed for the heating/cooling unit. However, the present invention should not be limited only to this.

Alternatively, the apparatus may be suitably changed or modified to an apparatus of the type including an electrical heater and a cooling fan in combination, an apparatus of the type using pure water or liquid having a high degree of electrical insulation as a heat conducting medium or the

like apparatus.

Next, description will be described below as to a second embodiment of the present invention.

Fig. 3(a) is a schematic view illustrating an apparatus including a laser scanner in accordance with the second embodiment.

The apparatus is so constructed that a differential temperature is previously divided into a plurality of stages $G1$ --- Gn as shown in Fig. 3(b), the differential temperature and an amount of deviation corresponding to the latter are stepwise calculated for the respective stages $G1$ --- Gn in such a manner as shown in the foregoing table and the temperature of the position sensor is continuously detected so that data indicated by the position sensor are properly corrected by monitoring what stage among the stages $G1$ --- Gn is assumed by the differential temperature. Thus, the apparatus has a characterizing feature which consists in that it includes a scanner temperature detector 3 located in the proximity of a scanner position sensor 2 in the scanner 1, a correction temperature range setter 14 adapted to calculate a difference Δt between the detected temperature and the preset reference temperature and determine to what stage among the preset stages $G1$ --- Gn a value derived from the above calculation corresponds, a correction amount calculating section 15 for calculating an amount of

correction in dependence on an output from the correction temperature range setter 14 and scanner controlling means 16 for controlling correction of a signal i_o indicative of a positional command on the basis of an output from the correction amount calculating section 15.

Other components constituting the apparatus are substantially identical to those in the first embodiment. Thus, components having the same function as those in the first embodiment are identified by same reference numerals.

By using the aforementioned means, the signal i_o indicative of a positional command issued on the basis of printing data is continuously corrected in response to variation in temperature of the position sensor and a driving electric current is fed to the magnetic driver 9 on the basis of results derived from a comparison made between printing data i_o' after correction and a feedback signal i_f from the scanner position sensor whereby the mirror 10 is turned by turning movement of the scanner 1.

Here, it is assumed that an amount of deviation at the central value of the temperature range at a certain stage G_m is added to the initial data by the scanner controlling means.

The apparatus as constructed in the above-described manner assures that an amount of drift relative to the initial data provided by the X/Y scanner as the latter has

an increased temperature is calculated so that the drift is properly corrected so as to allow a value of the command signal to be kept constant within the preset temperature range. This makes it possible to very easily perform fine machining with high accuracy.

It should be added that if the differential temperature is finely divided into more stages, an accuracy can be improved much more while it is less affected by the drift. Accordingly, it suffices that a number of stages are adequately selected in correspondence to a required accuracy. Thus, it is possible to easily perform proper positional setting in correspondence to a degree of requirement.

CLAIMS

(1) An apparatus including a laser scanner usable for the purpose of controlling the position where a laser beam is radiated (representative of the direction of scanning) by turning a mirror by driving means adapted to be actuated in response to a signal detected by a position sensor, characterized in that said apparatus further includes;

scanner temperature detecting means for detecting the temperature of said position sensor and

controlling means for compensating the temperature of the position sensor on the basis of an output from said scanner temperature detecting means

whereby operation of said driving means is controlled by said controlling means.

(2) An apparatus including a laser scanner as claimed in claim 1, characterized in that said controlling means includes;

environment temperature detecting means for detecting an environment temperature and

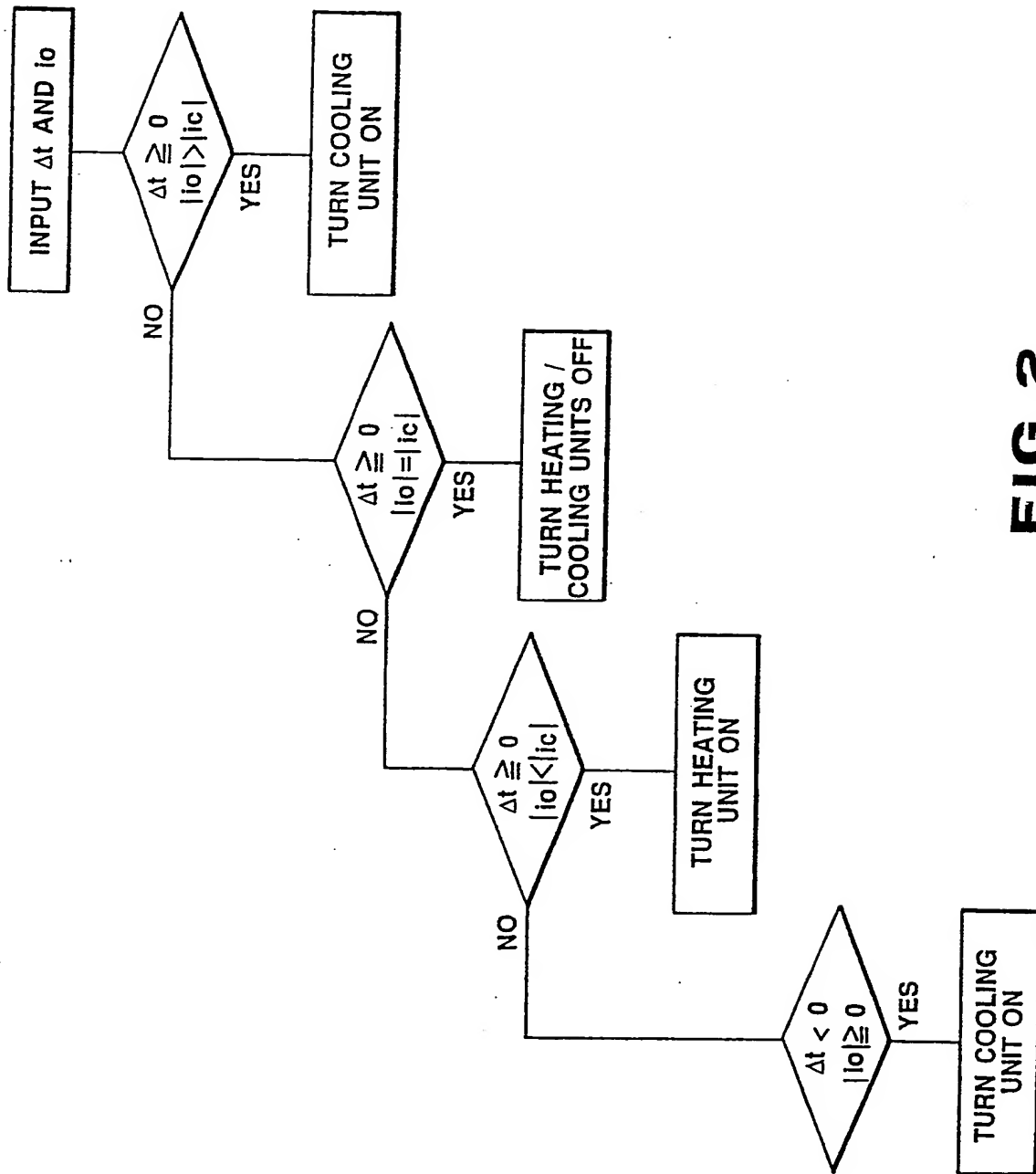
temperature controlling means for controlling the temperature of the position sensor on the basis of an output from said environment temperature detecting means and an output from said scanner temperature detecting means so as to allow the temperature of the position sensor to be kept

constant at all times.

(3) An apparatus including a laser scanner as claimed in claim 1, characterized in that said controlling means includes;

table setting means for setting a data correction table while a positional deviation caused by variation in temperature has been previously detected and

drive controlling means for controlling the driving of a scanner on the basis of a value of correction derived from referring of a value detected by said scanner temperature detecting means to said data correction table.

**FIG. 2**

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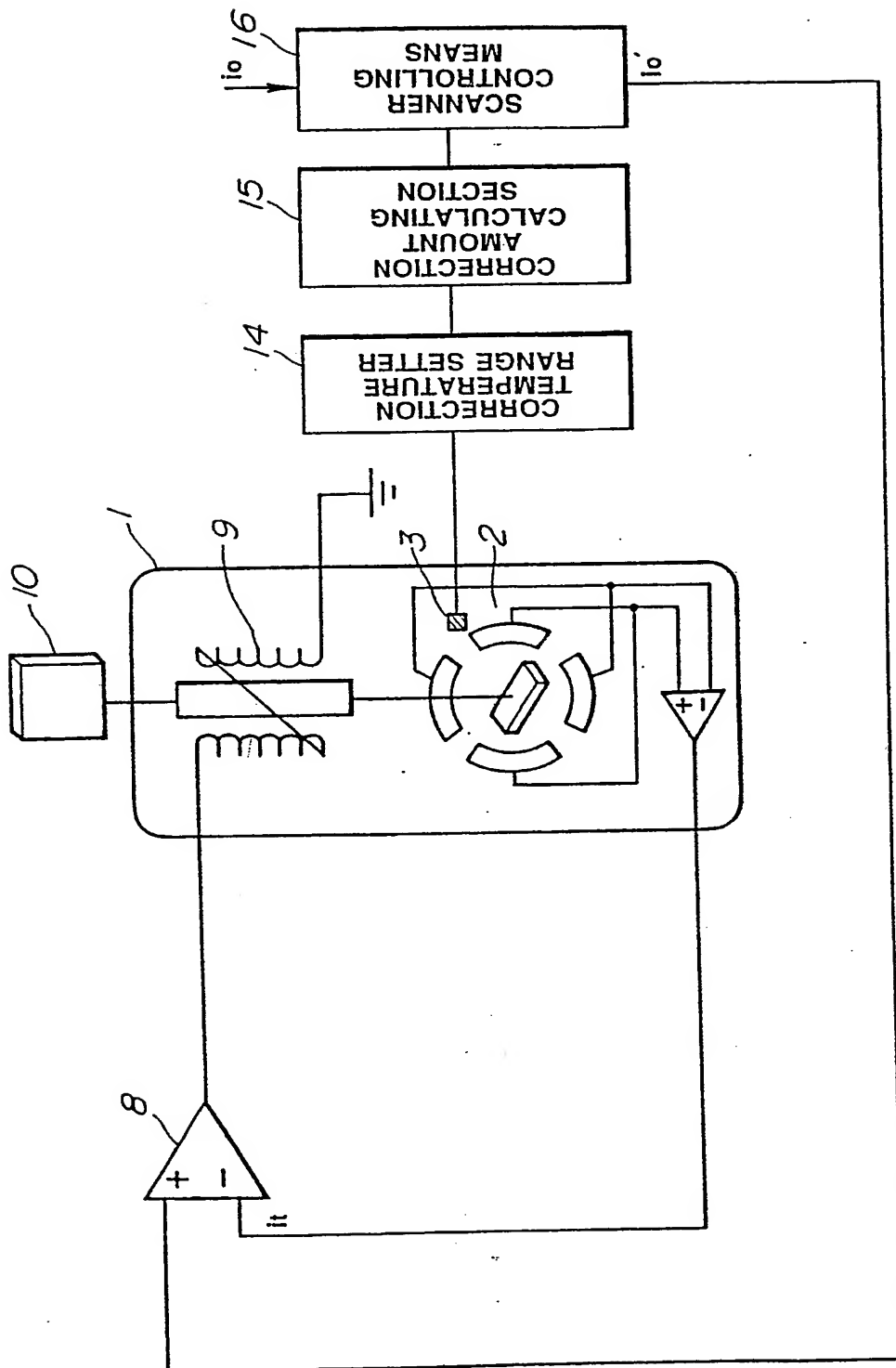
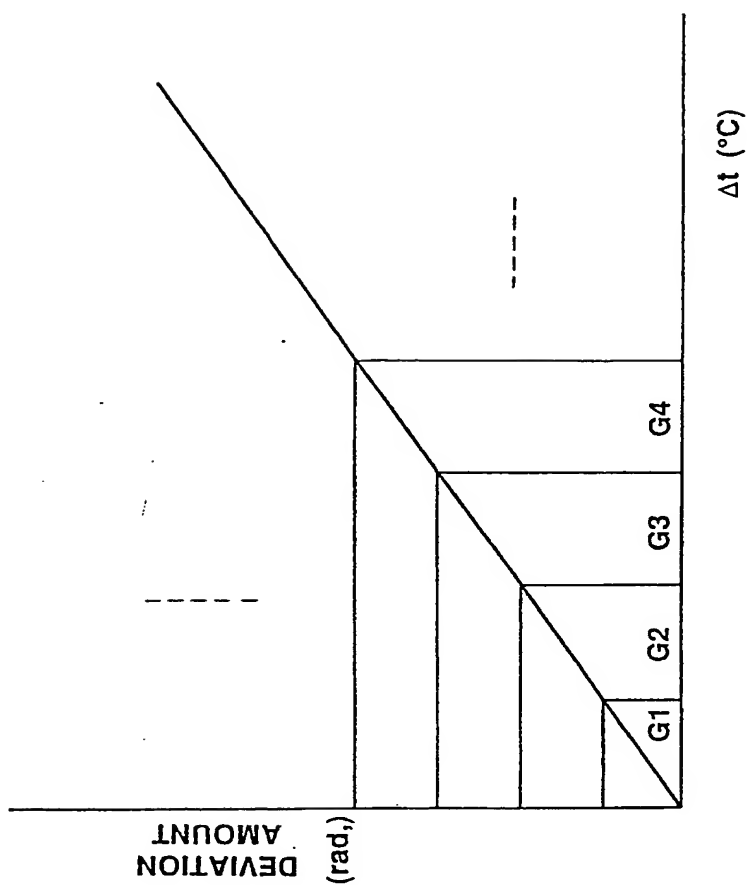
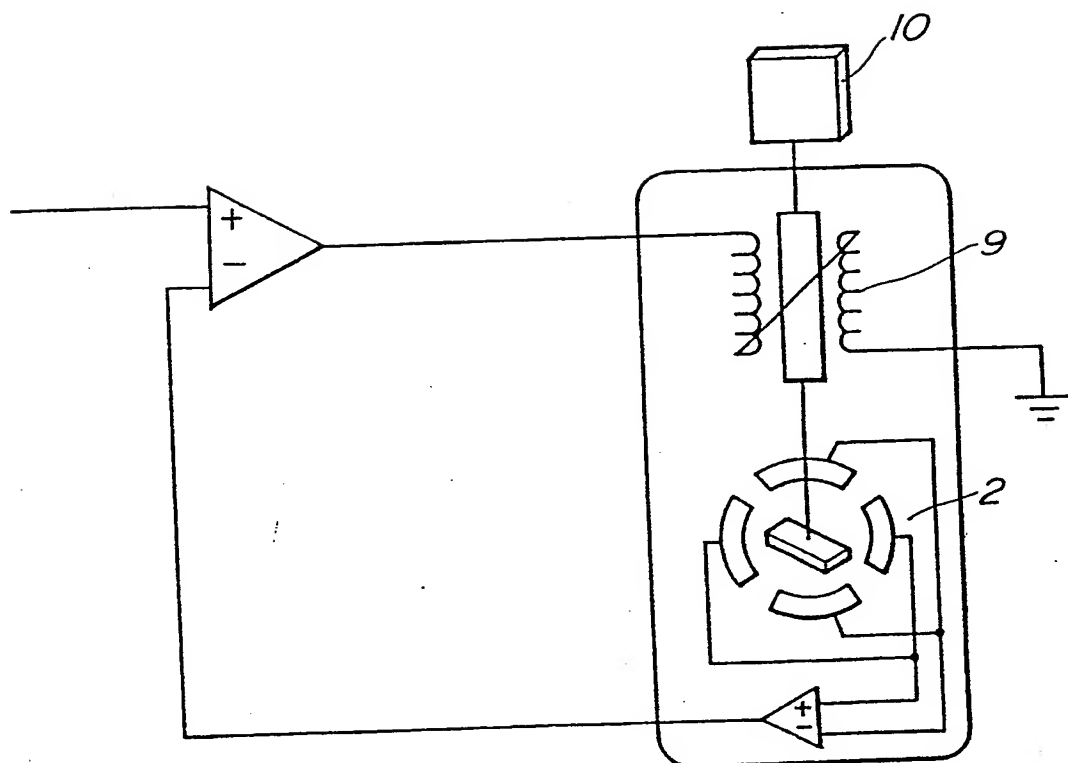


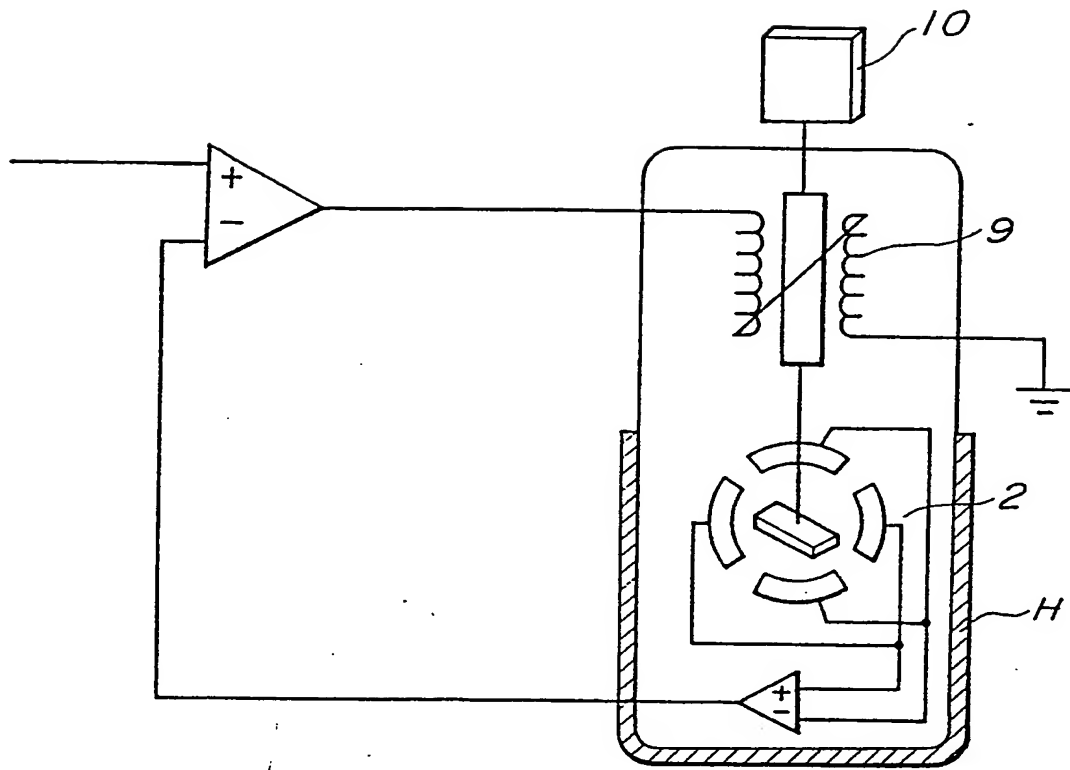
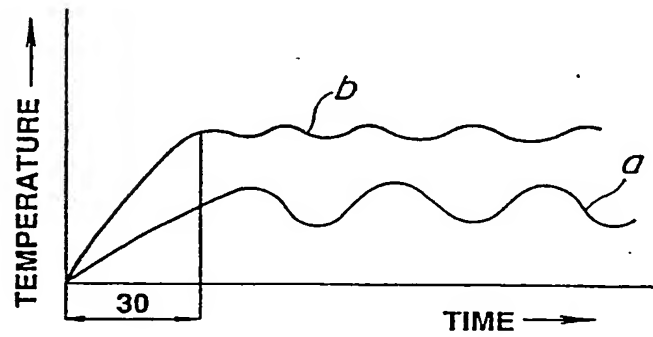
FIG. 3(a)

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**FIG. 3(b)**

**FIG. 4**

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**FIG. 5****FIG. 6**

INTERNATIONAL SEARCH REPORT

International Application No

PCT/JP87/00568

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl ⁴ G02B26/10, B23K26/08		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
IPC	G02B26/10, G01B7/30, B23K26/08 G01D5/24, G01D3/04	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
Jitsuyo Shinan Koho	1933 - 1987	
Kokai Jitsuyo Shinan Koho	1972 - 1987	
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category ⁶	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
P, Y	JP, A, 61-210318 (NEC Corporation) 18 September 1986 (18. 09. 86) Column 2, line 13 to column 3, line 2 (Family: none)	1-3
Y	JP, A, 55-87122 (Canon Inc.) 1 July 1980 (01. 07. 80) & US, A, 4370019	1-3
P, Y	JP, A, 61-235091 (Hitachi, Ltd.) 20 October 1986 (20. 10. 86) (Family: none)	1-3
Y	JP, A, 59-97786 (NEC Corporation) 5 June 1984 (05. 06. 84) Column 2, lines 2 to 20 (Family: none)	1-3
Y	JP, A, 56-137158 (Honda Motor Co., Ltd.) 9 November 1984 (09. 11. 84) column 2, lines 11 to 23 & FR, B1, 2479473 & GB, B2, 2105494 & US, A, 4408490 & DE, A1, 3112259	1, 2
<p>* Special categories of cited documents: ¹⁵</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"Z" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ³		Date of Mailing of this International Search Report ²
October 13, 1987 (13.10.87)		November 2, 1987 (02.11.87)
International Searching Authority ¹		Signature of Authorized Officer ²⁰
Japanese Patent Office		

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y

JP, A, 59-197818 (Yokogawa Hokushin
Electric Corporation)
9 November 1984 (09. 11. 84)
Column 10, line 9 to column 11, line 5
(Family: none)

1, 3

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE¹⁰

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers..... because they relate to subject matter¹² not required to be searched by this Authority, namely:

2. ☐ Claim numbers..... because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out¹³, specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING¹¹

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ The protest accompanied the payment of additional search fees

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